ON THE BREEDING HABITS AND FECUNDITY OF THE SNAIL. *LIMNÆA LUTEOLA*.[1] LAMARCK (FORMA-TYPICA)

BY

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(*With two plates and two graphs*)

The breeding habits and fecundity of *Limnæa luteola* Lamarck forma typica [2] were the subject of my observations during the past three years. The observations were made on (1) individuals reared in the aquaria in the laboratoy, (2) individuals kept isolated in the laboratory, (3) individuals kept in big troughs of water in the open air (in a garden), and (4) individuals in their natural haunts.

The species in question is the only species available in Tirupati and my observations are practically confined to it. But I had an occasion once to get live specimens of *Limnæa acuminata* from elsewhere and they also were under observation for some time. So far as fecundity is concerned *Limnæa acuminata* also presents the same features as *Limnæa luteola*.

Limnæa luteola seems to attain sexual maturity in about ten months. It is not definitely known how many times an individual breeds during its lifetime. In attempting to find out this, two difficulties were experienced. One was that the exact duration of life of individuals could not be definitely ascertained, for the adult individuals could not be kept alive in the aquaria for over five or six months in spite of all possible care bestowed on them. Young individuals hatched from the eggs could however be kept alive much longer. But from observations made on the rate of growth of the individuals, on the size attained in a year by individuals kept under natural conditions in open surroundings, and judging from the maximum size attained by individuals we may assign to this species of *Limnæa* three years as the duration of life. On the strength of my observations, I can confidently assert that it is more than two years.

The other difficulty was that of ascertaining the exact breeding season. I could collect eggs at all times of the year. At first it seemed as though the species was breeding right through. But I kept the individuals isolated in the laboratory and observed that they breed for about four to five months. Individuals lay eggs in abundance for a time and then gradually cease their breeding. That eggs are found in abundance at all times of the year is to be explained as due to different sets of individuals reaching sexual maturity at different periods of the year, and thus some individuals or other in a tank are found breeding right through. We cannot therefore speak of any definite breeding season for this species of *Limnæa*. The individuals of the species have each their own breeding period of life, but there seems to be no breeding season for the species as a whole.

Limnæa is of course oviparous like the majority of *Mollusca*. An individual about to lay eggs attaches itself by its foot to a leaf, or in the aquarium, to the wall of the aquarium. It remains steady for a short while and as the mass of eggs embedded in the jelly-like substance issues out, the animal recedes very slowly. It takes about twenty to twenty-five minutes for an animal to lay a batch of about 120 eggs.

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[1] From a paper read before the Indian Science Congress (1927) held at Lahore.

[2] My thanks are due to Major Seymour Sewell and Dr. H. S. Rao for the identification of species.

The eggs are laid as indicated above in capsules embedded in a jelly-like gelatinous substance. This jelly is more abundant than in the case of egg masses of *Indoplanorbis exustus* and the egg capsules are unlike those of *Indoplanorbis exustus* in not being tough. Each batch of eggs contains usually three or four rows of oval eggs capsules. The egg masses are laid on some substratum like leaves, stones, shells of other *Mollusca* like *Vivipara*, *Pila globosa*, etc. The length of the batch varies according to the number of eggs. I have often come across batches nearly 2″ long. The average number of eggs in a batch is about thirty-two.

For observations on their fecundity, I kept a number of individuals isolated. The statistics for the frequency of laying eggs and for the variation in the number comprising a batch are given in the end. It will be sufficient here to refer simply to the general feature of the fecundity of *Limnæa luteola*.

(1) Average frequency of laying eggs per individual :—Once in two days.

(2) Average number of eggs individuals per batch :—Thirty-two.

Generally speaking an individual under normal conditions lays eggs once in about two to three days, sometimes more frequently, sometimes with regularity. In the course of about three months an individual could lay as many as forty-seven batches. The average number of eggs per batch for this individual was thirty-four.

Mr. Ramanan [1] speaking of the Madras specimens, says that the spawn was laid once in a fortnight. Professor J. A. Thomson[2] speaking of *Limnæa stagnallis* says, ' the eggs are laid through the summer and attached in clumps of about thirty to water weed, each clump being surrounded by a curved mass of jelly about an inch long. . . . They hatch out in a month.' It is evident that *Limnæa luteola* of Tirupati differs in these respects not only from its British cousin but also from the Madras one, for in the species under consideration, eggs hatch out in about ten days and the eggs are laid throughout the year.

The number of eggs in the successive batches laid by an individual alternately rises and falls—(*vide* statement and the graph, page 160). If, for example a large number of eggs, say fifty in number, are laid in a batch, the number in the next batch will be something less ; and after one to three batches it usually goes up again, only to fall again. Below are noted the number of the eggs in the successive batches laid by an individual. More or less the same phenomenon has been noted in a large number of individuals.

Batch No.	No. of eggs	Batch No.	No. of eggs
1	39	14	28
2	54	15	6
3	39	16	21
4	20	17	30
5	60	18	30
6	39	19	42
7	45	20	25
8	29	21	30
9	51	22	16
10	33	23	23
11	21	24	29
12	35	25	19
13	52		

Another feature worth noting and which has been observed in some of the individuals examined, is that with the increase in the number of batches laid

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[1] *Non-marine Mollusca of Madras and Its Vicinity* by V. V. Ramanan (1900), Premier Press, Madras.

[2] *The New Natural History*, by J. A. Thompson, page 906 (1926). George Newnes, Ltd., London.

by the individual, the number of eggs in the batch generally tends to decrease. The following figures show the average for every successive batches of eggs laid by an individual.

1st five batches	...	...	...	...	42
2nd ,, ,,	...	...	...	...	38
3rd ,, ,,	...	...	...	...	33
4th ,, ,,	...	...	...	...	25
5th ,, ,,	...	...	...	...	25

It is clear that the average tends to fall with the rise in the number of batches laid by the individual.

Taking three years as the minimum duration of life of *Limnæa* it is possible to estimate the number of eggs laid by a single individual. An individual seems to breed for about four months in the year, though all the individuals in a tank do not breed at the same time of the year. During these four months about forty to fifty batches of eggs are laid, with about thirty-two eggs in each batch on the average. Thus in three years a single individual might lay about five thousand eggs. This is quite a prolific breeding. In their natural environment the breeding appears to be more prolific, for, I come across egg masses which are often much longer than those laid in captivity. Ordinarily one embryo is contained in an egg, but rarely two, three, seven or even nine embryos are found. The young ones hatch in about ten to eleven days in the cold season and in about nine to ten days in the summer season.

Limnæa are hermaphrodite. Annandale and Prashad [1] state that certain species are functionally protandrous and pair when the male organs are ripe. Annandale and H. S. Rao [2] state that they have much indirect evidence to show that this condition prevails in most species. They also state that prostrate and spermatheca are fully developed in the same individual only rarely and that egg masses are rare in tanks in which the snails are mating and conversely, when individuals are mating, egg masses are not common. I cannot speak the same of the species in Tirupati. I find the egg masses are common right through the year but the mating of the individuals takes place only from March to August. That is, even when the individuals are mating, the egg masses are quite plenty. I have closely watched the mating individuals and after separating them immediately after mating, kept a record of their subsequent behaviour.

First as to mating :—Of the two individuals that pair one is frequently slightly bigger and this is usually the functional male. The other is a little bit smaller and is the functional female. The copulation between the individuals lasts for about forty minutes and is not reciprocal. The individuals that are to mate come to the surface of the water. The functional female attaches itself by means of its foot to some foreign object, the side of the jar in my aquarium, and remains steady. The other individual attaches itself to the shell of the former and protrudes the whitish penis sheath and introduces it into the other animal. The movements of the penis as the sperm passes along are clearly visible through the translucent penis sheath. The mantle opening which can be seen by the side of the penis sheath is opened about every three minutes to renew the air in the mantle cavity. Sometimes the air is renewed at much longer intervals. On one occasion three individuals were found copulating together. Sometimes both float to the surface.

After mating both the individuals sometimes lay eggs that very day : sometimes one day or two later but never much later. So we cannot always conceive of the sperms being stored up for any length of time before the ova are fertilized.

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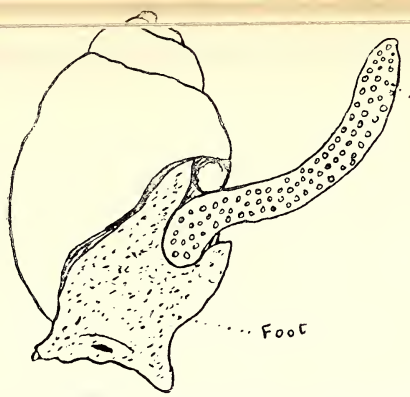
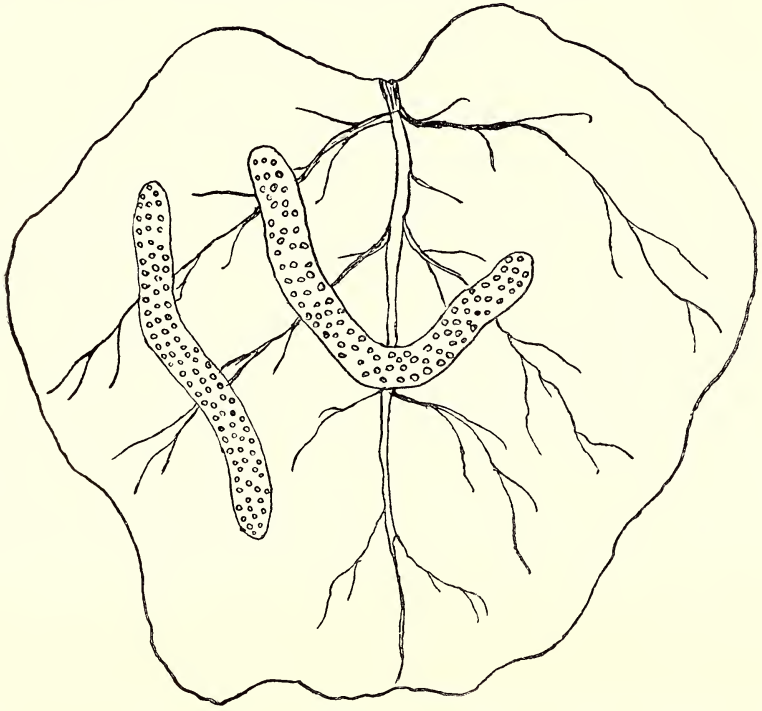
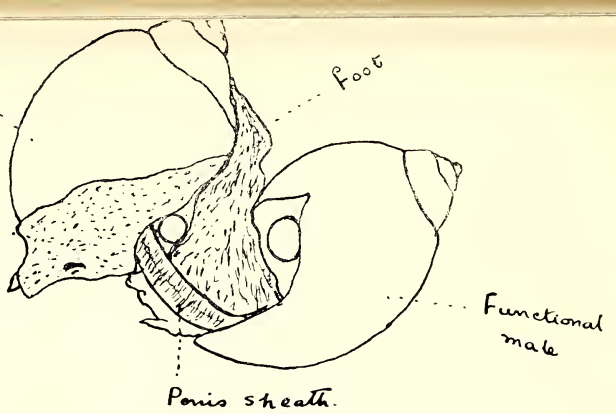
[1] *Records of the Indian Museum*, vol. xxvii, p. 138 (1925).
[2] *Ibid.*



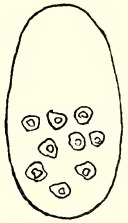
1. *Limnæa* LAYING EGGS ON THE SIDE OF A GLASS JAR.



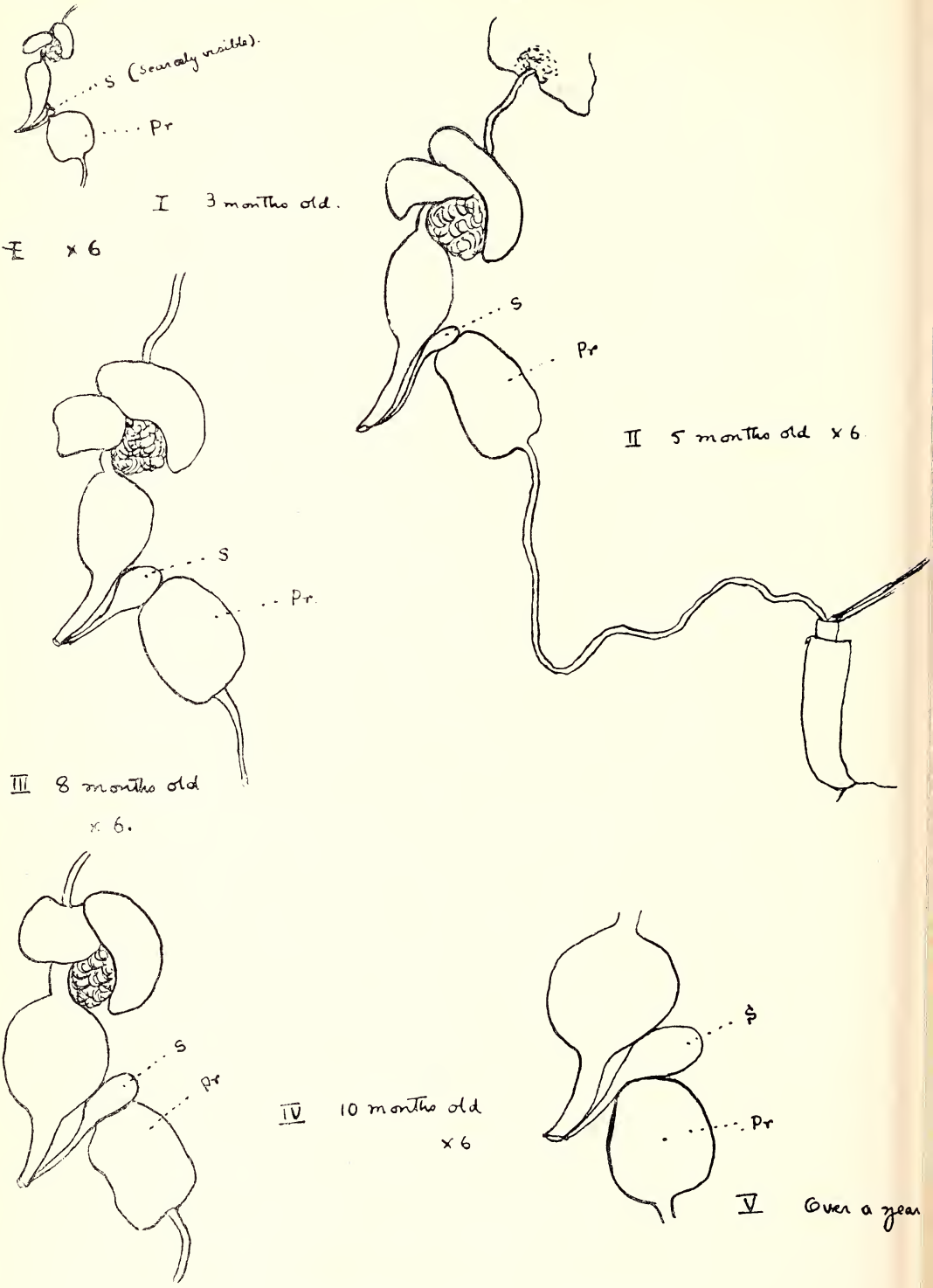
2. EGGS LAID ON THE UNDER SURFACE OF A FLOATING PIECE OF LEAF.



3. MATING IN *Limnæa luteola*.



4. EGG WITH NINE EMBRYOS.



Pr. = Prostrate Gland ; S. = Spermatheca.

SKETCHES SHOWING RELATIVE DEVELOPMENT OF MALE AND FEMALE GENITALIA AT DIFFERENT PERIODS OF LIFE.

Below is the record of two individuals that mated on the 23rd August, 1925.

COPULATING INDIVIDUALS

Date	Functional female No. of eggs	Functional male No. of eggs
23rd August, 1925	23	27
24th ,, ,, ...	...	...
25th ,, ,, ...	...	...
26th ,, ,, ...	...	49
27th ,, ,, ...	20	...
29th ,, ,, ...	17	24
31st ,, ,, ...	17	13
2nd September, and so on ...	16	19
	25	21
	29	16
	16	15
	11	15
	12	18
	7	13
	9	12
	6	16
	died	13
		12
		3
		5
		9
		3
		4

Then again the reproductive organs of two mating individuals were examined. In the functional female the prostrate and the spermatheca were both well developed. The spermatheca and its duct contained sperms. The hermaphrodite gland showed sperms and ova well developed.

In the functional male also both the spermatheca and prostrate were well developed but in the spermatheca there were no sperms as in the functional female.

This would show that in both the mating individuals both sperms and ova are ripe and the male and female genitalia are equally ripe. And we have already seen that both the mating individuals begin to lay eggs soon after mating.

A few individuals that had been laying eggs for a long time were examined. They showed both sperms and ova well developed in the hermaphrodite gland. The spermatheca also contained sperms.

Young individuals of about four months or a little younger were examined. The spermatheca was minute and the uterus was small. In the hermaphrodite gland, sperms were developing but no ova. Again individuals of about 7 or 8 months were examined. The spermatheca was not yet of its maximum size but the prostrate was well formed. The hermaphrodite gland showed sperms but ova were not quite ripe.

Individuals are certainly protandrous in the first year of their life, but considerable time does not lapse between the development of the two sets of genitalia. In older individuals both ova and sperms are ripe and both the genitalia are ripe at the same time. This suggests the possibility of self-fertilization, for I note that isolated individuals can breed for a long period of four months and of the mating individuals, the functional male also lays eggs soon after mating, though it does not show signs of having received sperms from another individual prior to laying eggs. This problem needs a thorough investigation probably from a cytological standpoint.

The fact that isolated individuals can lay considerable number of eggs for a long period would show that the ova get fertilised batch after batch. And as the stock of germ cells gets exhausted there is a decline in the number of eggs laid. But the significance of the interesting features shown elsewhere about

the fecundity is not known. Sometimes I find that the number of eggs laid by an individual having come very low, suddenly rises up.

Sedgwick mentions of cases of *Limnæa* that have been kept isolated for life and that have laid eggs. These, he says, might be cases of parthenogenesis. But there is no parthenogenesis in the species I have been observing.

Another interesting feature of breeding of *Limnæa* has been noticed. The fecundity seems to be susceptible to environmental influences. Though I am not in a position to give detailed statistics at present to show the relation between fecundity and environment, yet sufficient evidence is available for me to state that environmental variations do affect the breeding of *Limnæa luteola*.

For a month a number of individuals were kept isolated in separate jars. The water was not changed and the food which consisted of leaves of *Vallisneria* was not renewed. Many of these individuals had been laying eggs regularly but under the changed conditions the breeding ceased abruptly. Again a number of individuals were kept crowded for about a week without food. The number of eggs laid was very low. But the same individuals after being placed in fresh water with a fresh supply of leaves, began laying eggs regularly. This was observed on many occasions. It is worth finding out what exactly is the connection between fecundity and nutrition here.

In fine the breeding habits of *Limnæa luteola* present many problems of interest which need elucidation. The regular rise and fall of the number of eggs laid, the capacity of isolated individuals to breed for a prolonged period, the phenomenon of both the mating individuals laying eggs soon after mating, though mating is not reciprocal, the influence of environmental changes on breeding,—these are some of the problems that require explanation. It is also necessary to find out where in the genitalia, and how, when, and how often, the fertilization of ova takes place.

NOTE ON THE STATEMENTS AND GRAPHS APPENDED TO THIS ARTICLE.

Statement A, Page 160

This statement shows the variation in the number of eggs in the successive batches laid by an individual.

Statement B, Page 162

This shows the total number of eggs in the batches recorded and the average per individual per batch.

Statement C, Page 162(A)

This shows the frequency with which eggs are laid.

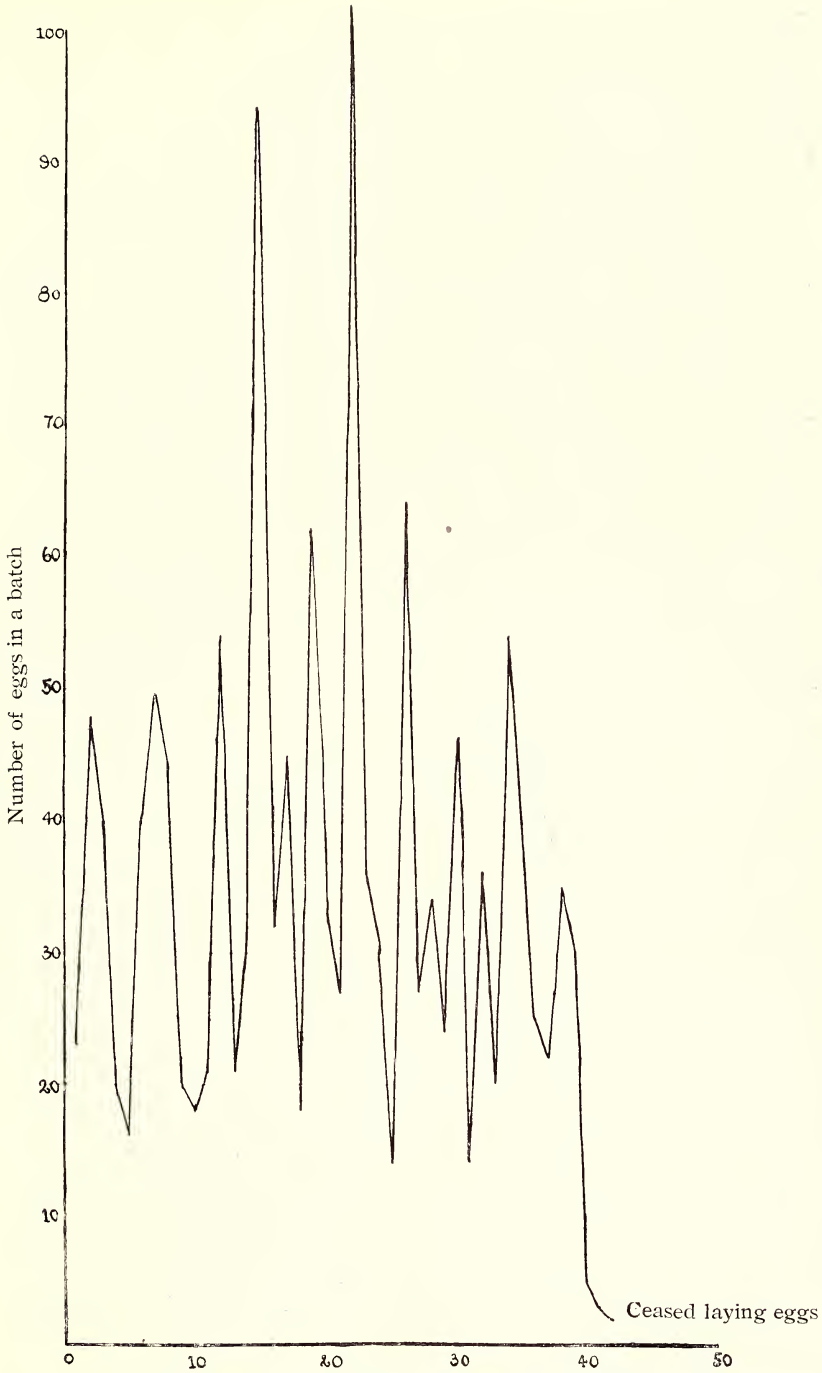
Graph I

This graph shows the variation in the number of eggs in successive batches laid by an individual. It will be seen that after rising high the number of eggs per batch comes low and after one to three batches rises again. Then it comes low and so on.

Graph II

This graph will give an idea of the frequency with which the eggs are laid. It will be seen that eggs are laid successively for two to four days and then there is a break after which eggs are again laid regularly.

Graph I



GRAPH SHOWING THE NUMBER OF EGGS IN SUCCESSIVE BATCHES LAID BY INDIVIDUAL C.